# Validation of satellite remote sensing for coastal turbidity monitoring by sediment transport modelling


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## Introduction

Satellite images of coastal areas can show the spatial distribution of fine suspended sediments at the surface of large water bodies. After atmospheric correction of the raw image, the intensity of the reflectance in selected frequency bands can be converted into suspended particulate matter (SPM) concentrations. Calibration and validation of the conversion algorithm requires field data (ground truthing) which is time demanding, labour intensive and restricted to a few locations. In addition, comparison can be made with images from other satellites and SPM maps generated by computer simulations.

Proba-V is a Belgian satellite designed for vegetation monitoring with daily coverage at 300 m and a 5-daily coverage at 100m resolution. The sensor onboard the satellite records data up to at least 100 km away from the coastlines. The good image quality provides opportunities for turbidity retrieval in coastal waters. Combining turbidity products from Proba-V and other typical ocean colour sensors allows for better monitoring of turbidity in dynamic near shore areas and it increases the chance to detect short term events in particular for areas with rapid changing cloud cover. An evaluation of the added value of Proba-V for monitoring turbidity, taking into accounts its limitations, is presented by Knaeps *et al.* (2017). They present the turbidity retrieval algorithm and the direct validation with in-situ data (normalized water leaving radiance sensors, SPM concentrations from OBS sensors on buoys and sampling; Fig.1) in more detail.

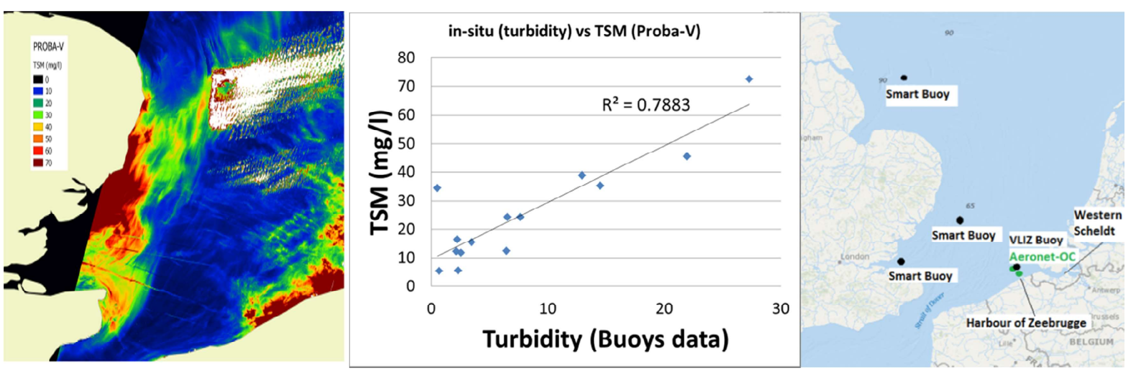


Figure 1. Left: PROBA-V TSM product (acquisition date/time 21 April 2015/11:06); Middle: Direct validation of PROBA-V TSM data through comparison with in-situ turbidity data from CEFAS smart buoys and VLIZ buoy. Right: Buoy locations.

The present study focusses on the indirect validation method, consisting of an intercalibration with a sediment transport model (using TELEMAC, solving for hydrodynamics, waves and SPM concentrations) which is used to take into account the turbidity variations between subsequent image acquisitions.

## Assessing the errors and similarities of simulated SPM maps

A methodology has been developed for assessing the errors and similarities of simulated SPM maps compared with the remote sensing images. The quality of an image signal that is being evaluated can be thought of as a sum of an undistorted reference signal and an error signal. Thus, to assess the quality of simulated results, it is necessary to quantify the error signal. The methodology in this study mainly consists of three approaches.

The first one is called the distance based approach, which is used to quantify the errors between simulated results and remote sensing images. The Euclidean distance is adopted as the error index and it can be calculated at different length scale. This can give give an indication of the quality of simulated results in a defined sub-domain and show the model performance at a relatively large scale.
The second approach is an assessment based on structure similarity. This approach is brought up to compensate some drawbacks in the distance based approach. The reason is that the same distance metrics may come from very different types of errors, some of which are more visible than others. image signals are highly structured, while the distance metrics are based on pointwise signal differences and independent of the underlying signal structure. Hence, instead of estimating perceived errors, perceived changes in structural information variation can be measured in the framework of a Structural Similarity Index (SSIM) as developed by Wang et. al (2004). This index is calculated from the simulated results and is used to quantify the Structural Similarity between a modelled SPM map and a remote sensing image.
The third approach is based on pattern recognition and comparison. A method for calculating 2D cross-correlation is adopted. In general, cross-correlation is a measure of similarity of two series as a function of the displacement of one relative to the other. It is commonly used for searching a shorter, known feature or local pattern in a longer signal. It is also a method of estimating the degree to which two series are correlated. With 2D cross- correlation, it is possible to find the local pattern shift in the simulated results and quantify the displacement of simulated patterns and the ones captured in the remote sensing image.
The methodology is also applicable to assess the similarity in temporal variations. Instead of directly using simulated results at certain time frame, a temporal variation can be calculated from different time steps. Then, it is possible to apply the above three approaches to the temporal variations from the remote sensing data and the simulated results, respectively. The purpose is to check if a similar trend can be found in both remote sensing images and simulated SPM maps.

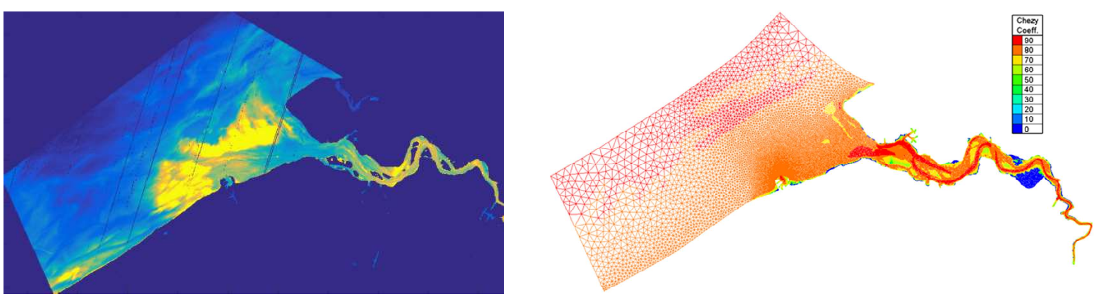


Figure 2. Left: PROBA-V image cropped to the modelling domain, of which the mesh and roughness map (cf. Bi & Toorman, 2015) is shown on the right.

Different model set-ups will be applied in order to assess the importance of potential 3D effects (e.g. vertical stratification) and the importance of flocculation (Bi *et al.*, 2016) and how they may affect the interpretation of remote sensing images.

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## References

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